PB84-130467

Agrochemical Hazards in Aquatic Systems and Evaluation of Such Hazards with Emphasis on Developing Countries

(U.S.) Environmental Research Lab.-Duluth, MN

1983

U.S. Department of Commerce
National Technical Information Service
NTIS

PB84-130467

EPA-600/D-84-020
1983

Agrochemical Hazards in Aquatic Systems and Evaluation of Such Hazards with Emphasis on Developing Countries

by

Armond E. Lemke, Research Biologist
U.S Environmental Protection Agency
Environmental Research Laboratory-Duluth
6201 Congdon Boulevard
Duluth, Minnesota 55804

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
DULUTH, MN 55804

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/D-84-020	2.
3. RECIPIENT'S ACCESSION NO. PB84 130467	
4. TITLE AND SUBTITLE Agrochemical Hazards in Aquatic Systems and Evaluation of Such Hazards with Emphasis on Developing Countries	5. REPORT DATE 1983
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) A. E. Lemke	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Duluth, MN 55804	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Same as above	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE EPA-600/03

15. SUPPLEMENTARY NOTES
International Conference on Environmental Hazards of Agrochemicals in Developing Countries, UNARC, Alexandria, Egypt, Nov. 8-12, 1983

16. ABSTRACT

Many developing countries are lacking protein in the diets of their population. Aquatic systems are good sources of protein in many areas with fish and shellfish as the main sources. The misuse of agrochemicals can directly or indirectly affect the use and suitability of these protein sources as food. Problems are found in three main areas: eutrophication which changes species production, direct toxicity to aquatic species and bioconcentration of various materials to excessive amounts. The best solution is judicious purchase and use of agrochemicals. Lacking this, testing is necessary to predict and prevent problems and several methods will be enumerated. Particular emphasis will be placed on testing facilities and personnel. A substantial bibliography will be included.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* unclassified	21. NO. OF PAGES 20
	20. SECURITY CLASS *(This page)* unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ABSTRACT

Many developing countries are lacking protein in the diets of their population. Aquatic systems are good sources of protein in many areas with fish and shellfish as the main sources. The misuse of agrochemicals can directly or indirectly affect the use and suitability of these protein sources as food. Problems are found in three main areas: eutrophication which changes species production, direct toxicity to aquatic species and bioconcentration of various materials to excessive amounts. The best solution is judicious purchase and use of agrochemicals. Lacking this, testing is necessary to predict and prevent problems and several methods will be enumerated. Particular emphasis will be placed on testing facilities and personnel. A substantial bibliography will be included.

Developing countries are using agrochemicals in two main ways. They are either trying to produce enough food for their own people to reduce imports, such as in India, Indonesia, and Mexico, or are producing large amounts of agricultural products for export such as in Brazil. This use of agrochemicals in the form of fertilizers, plant pesticides, insecticides, and to a lesser degree such materials as hydraulic fluids and waste oils may cause problems if they reach the aquatic environment.

Aquatic systems provide a high protein food source which is often lacking in many peoples' diets in developing countries. In Kuwait, for example, the fisheries in the Gulf of Arabia provides a substantial amount of protein in the form of fish and shellfish, as does the Nile River fishery in Egypt and several of the rift lakes in Africa. The rice paddy and river systems in southwest Asia also are utilized to a substantial degree (82). These systems can be substantially impacted in an adverse manner in several ways. Fertilizers, for example, can cause eutrophication of water bodies, thus changing the species composition of the area (5). If severe enough, the fertilizers cause demise of the fish population by oxygen depletion when the algae dies and decays (95). The highly toxic insecticides can cause direct kills of fish and shellfish. Rice paddy fish culture or any small pond culture is particularly susceptible to this type of problem.

The hard pesticides such as DDT, dieldrin or benzine hexachloride, the gamma isomer being lindane, can kill directly. However, a much more serious problem is that of bioconcentration, or biomagnification, which can cause top of the food chain predators to be toxic because of the accumulated products when used as human food. Several other materials of a similar nature, like

polychlorinated biphenyls (PCBs) and polybrominated organics, can cause similar problems. Certain of these materials are found in hydraulic oils and transformer fluids. Heavy metals such as zinc, copper, and mercury can also bioconcentrate and are found in seed treatment and plant fungicides used in agriculture. The Minamata disease episode in Japan was through an aquatic system although the source was not agrochemicals.

What can be done to prevent or at least minimize the impact of agrochemicals on the very useful aquatic resource? The most important, in my mind, is education of the chemical users. I spent the first 20 years of my life on a dairy farm in the northcentral United States. I had a first hand experience with the lack of knowledge when using agrochemicals. When DDT first came out I applied it to a cat for flea control. The cat became ill, lost part of its hair but recovered. Cats were found to be very sensitive to DDT in subsequent research. Therefore users of all agrochemicals should be trained or closely supervised when applying all chemicals, even fertilizers. Good agricultural practices should be followed to reduce use of pesticides which are most needed when single species crops are repeatedly grown on the same land.

Poor tillage practices resulting in erosion and runoff, reduce yields and also are most detrimental to adjacent aquatic systems from turbidity, silting and pesticide runoff. Another way to minimize aquatic ecosystem damage from agrochemicals is to purchase or manufacture only those materials which are quickly degradable. Altough these materials must be applied more often, they do not bioaccumulate and cause little resistance buildup in the target pests. Similarly one should be sure that purchased materials are labeled completely. The agent that causes the toxicity in impure 2,4,5-T, a

brush killer, is dioxin while the actual plant toxin has little effect on aquatic systems.

Application practices also play a role in the contamination of aquatic systems with agrochemicals. Fertilizer applied in the row, or as side dressing after the plants are up and insecticides applied by hand to the plants, when the insects first appear results in better utilization of the materials and much less opportunity for contamination of the aquatic ecosystem than broadcast application on a time schedule.

If economic or other reasons preclude the previously listed precautions then testing and monitoring must be done to evaluate potential hazards to aquatic systems.

Protection of the aquatic resources, whether marine or fresh water, can be accomplished with a rather limited budget if knowledgeable personnel are sought out and they are heeded when potential application or manufacture of agrochemicals is contemplated. A minimum of one metals chemist, one organic chemist, and a marine and a fresh water biologist with some training in toxicity studies can provide a large amount of useful information. Ideally they should be in such a position in the respective political entities that they report directly to the office responsible for regulation and recommendation of agrochemical use and manufacture. This minimum group of scientific personnel can be augmented as funds become available and expertise increase.

Equipment and facilities for aquatic studies require one thing above all others for reliable and useful aquatic work. This requirement is a clean, and constantly available supply of dilution water, either marine or fresh. Without this water supply no aquatic program is worth the time spent to set it up.

In any test facility a water supply used for hatchery and rearing use for endemic species of aquatic animals is ideal. I was on a UNESCO mission to Kuwait in 1977 and set up a bioassay testing laboratory using water from their Institute for Scientific Research shrimp rearing facility as a source of test water with excellent results. Such a facility is also a good source of test animals. Fresh water testing facilities are often best served by a well or borehole, if no protected lake or river supply is available. This clean uncontaminated water supply is an absolute necessity because it is the base from which all biological data is evaluated and bad water of any kind will give biased and therefore inaccurate data. Such data is worse than none as it gives false results. After a water supply of sufficiently high quality is selected, the rest of the facilities and equipment can be added gradually. This should include a water tower or elevated tank of sufficient size to allow continued operation for at least eight hours in case of failure of the pumping system and to provide gravity feed to all holding and test equipment. (One large central pump with a back-up causes less trouble than several small ones.) A building of sufficient size is desirable so that holding and testing can be under the direct control of the biologists in charge because next to a good water supply, healthy test animals are a must to again eliminate bias and bad information.

Testing and holding equipment can be very sophisticated or very simple. Short term acute tests can be conducted in old glass jars if a good balance is available to weigh the chemicals and a few calibrated containers are used to make the dilutions. Lemke et al. (55) and Benoit (7) describe systems that can be made from stock parts and used to conduct flow through tests with aquatic organisms in fresh or salt water. Such a device was built both in Kuwait and Egypt by myself out of available parts. The only sophisticated

machinery needed are listed in the Lemke publication. Again, this equipment can start simple and more complex systems can be used as experience and need dictates.

Good analytical work at the levels that are necessary when insecticides in particular are of interest requires at least a gas chromatograph. For more sophisticated work, especially involving field samples with unknown exposures, a gas chromatograph - mass spectrometer system is needed. Initially a set of samples could be analyzed by a contract to a developed country laboratory with much less cost and much greater efficiency than acquiring such a system. For metals analysis an atomic absorption system is needed and these also vary in cost and abilities and can be tailored to expected uses.

Initial aquatic work in my opinion should take the form of attacking a known problem. As some of the developed countries have rather sophisticated programs underway, a lot of help is available. It is my suggestion that when the management decision is made to start an aquatic program a list of local problems which appear to require solutions be compiled. The designated official and any scientific people available then travel to at least two organizations which are in aquatic testing and discuss the problem list for relevance and ease of technical solution. The people from the developing country should then pick the first priority problem which is special for their area and which can be addressed with the least expenditure of money and limited outside help. If at all possible local scientists should be utilized, as they have a vested interest and will become the nucleus of any future expansion of the program. The above outlined evaluation laboratory will be directly applicable to any aquatic problem not just those associated with agrochemicals. The U.S., Holland, West Germany, Canada, Japan, and

England to name a few, have programs of various direction in marine and fresh water systems. These countries and others should be sources for doing emergency jobs, training of local people and resource centers, especially in methods, equipment, and technique development. However, the fact that many developing countries have endemic species not found in the developed countries requires at least some testing in the local areas to assure that the most prized food species is not the most sensitive and therefore destroyed even though exposure levels developed elsewhere are followed.

The use of agrochemicals appear to be a necessity to increase food production for developing countries. If judiciously used they are not usually detrimental to use of aquatic resources which are also important as food sources. The decision to keep the aquatic resources unharmed can be assisted by the testing program to present information which will allow national conclusions to be drawn. This in turn will allow the management decision to be based on fact rather than guesswork.

BIBIOGRAPHY

This bibliography has been collected from various sources. It is limited to recent reports, research papers and symposia. Older papers can be extracted from the bibliographies of the included citations. Included are citations for field effects, field studies, laboratory equipment and laboratory studies. It is not intended to be complete, but rather to act as a basis for an introduction to the effect of agrochemicals on the aquatic environment and some methods for attacking the problems.

REFERENCES

(1) Acher, A. J. 1981. The use of solar energy for waste water treatment. In: Shuval, H. I. (ed.), Developments in Arid Zone Ecology and Environmental Quality; International Meeting of the 12th Scientific Meeting of the Israel Ecological Society, Jerusalem, Israel, May 12-13, 1981. XIII+418 p. Balaban International Science Services: Philadelphia, PA, USA; Rehovot, Israel. Illus. Paper. ISBN 0-86689-005-X. 0(0): 313-314.

(2) Alexander, M. 1980. Bio degradation of toxic chemicals in water and soil. In: Haque, R. (ed.). Dynamics, Exposure and Hazard Assessment of Toxic Chemicals; Symposium, Miami Beach, FL, USA, Sept. 11-13, 1978. VIII+496 p. Ann Arbor Science Publishers, Inc., Ann Arbor, MI, USA. Illus. ISBN 0-250-40301-3. 0(0): 179-190.

(3) Allen, H. L. 1978. Low molecular weight dissolved organic matter in 5 soft water ecosystems a preliminary study and ecological implications. In: Sladecek, V. (ed.). Internationale Vereinigung Fuer Theoretische Und Angewandte Limnologie Verhandlungen. International Association of Theoretical and Applied Limnology, Proceedings, Vol. 20, Part 1 and 2. Copenhagen, Denmark, Aug. 8, 1977. IV+748 p. VIII+708 p. Illus. Maps. E. Schweizerbart'Sche Verlagsbuchhandlung: Stuttgart, West Germany. ISBN 3-510-54013-1 (Part 1); ISBN 3-510-54014-X (Part 2). pp. 514-524.

(4) Anderson, R. L., and D. L. DeFoe. 1980. Toxicity and bioaccumulation of endrin and methoxychlor in aquatic invertebrates and fish. Environ. Pollut (Series A) 22(2): 111-122.

(5) Arumugam, P. T., and J. I. Furtado. 1981. Eutrophication of a Malaysian reservoir effects of agro industrial effluents. Trop. Ecol. 22(2): 271-275.

(6) Bellan-Santini, D., and D. J. Reish. 1977. Use of marine peracarid crustaceans Isopoda and Amphipoda in toxicology studies. Rev. Int. Oceanogr. Med. 48: 103-106.

(7) Benoit, D. A., V. R. Mattson, and D. L. Olson. 1982. A continuous-flow mini-diluter system for toxicity testing. Water Res. 16: 457-464.

(8) Bingham, F. T. 1979. Bioavailability of cadmium to food crops in relation to heavy metal content of sludge amended soil. International Conference on Environmental Cadmium, Bethesda, MD, USA, June 7-9, 1978. Environ. Health Perspect. 28(0): 39-44.

(9) Bninska, M., and B. Zdanowski. 1978. Chemical composition of bottom sediments in lakes with induced eutrophication. Pol. Arch. Hydrobiol. 25(1-2): 35-40.

(10) Bradley, R. M., and D. Cabral, Jr. 1979. The quality of run-off from an irrigated market garden area in Brazil. Water Res. 13(7): 589-598.

(11) Breteler, R. J., I. Valiela, and J. M. Teal. 1981. Bioavailability of mercury in several northeastern USA spartina ecosystems. Estuarine Coastal Shelf Sci. 12(2): 155-166.

(12) Brewer, J. W. 1979. Toward optimal impulsive control of agro ecosystems. In: Halfon, E. (ed). Theoretical Systems Ecology: Advances and Case Studies. XVI+516 p. Academic Press: New York, NY, USA; London, England. Illus. ISBN 0-12-318750-8. 0(0): 401-418.

(13) Brewer, W. S., and D. Althaus. 1982. Degradation kinetics of trifluraline treflan by aquatic microbial communities. 82nd Annual Meeting of the American Society for Microbiology, Atlanta, GA, USA, March 7-12, 1982. Abstr. Annu. Meet. Am. Soc. Microbiol. 82(0): Abstract 084.

(14) Bryan, G. W. 1979. Bioaccumulation of marine pollutants. Meeting on the Assessment of Sublethal Effects of Pollutants in the Sea, May 24-25, 1979. Philos Trans. R. Soc. Lond. B. Bio. Sci. 286(1015): 483-506.

(15) Buikema, A. L., Jr., B. R. Niederlehner, and J. Cairns, Jr. 1982. Biological monitoring 4. Toxicity testing. Water Res. 16(3): 239-262.

(16) Chang, J. C., P. B. Taylor, and F. R. Leach. 1981. Use of the microtox assay system for environmental samples. Bull. Environ. Contam. Toxicol. 26(2): 150-156.

(17) Cherry, D. S., R. K. Guthrie, F. F. Sherberger, and S. R. Larrick. 1979. The influence of coal ash and thermal discharges upon the distribution and bioaccumulation of aquatic invertebrates. Hydrobiologia 62(3): 257-268.

(18) Collingwood, R. W. 1978. The dissipation of phosphorus in sewage and sewage effluents. In: Porter, R., and D. W. Fitzsimons (eds.). CIBA Foundation Symposium, Vol. 57. Phosphorus in the Environment: Its Chemistry and Biochemistry. London, England, Sept. 13-15, 1977. IX+320 p. Illus. Elsevier/Excerpta Medica/North-Holland: Amsterdam, The Netherlands; Elsevier/North-Holland, Inc., New York, NY, USA. ISBN 0-444-90031-4. pp. 229-238.

(19) Commoner, B. 1977. Cost risk benefit analysis of nitrogen fertilization a case history. Ambio. 6(2-3): 157-161.

(20) Crecelius, E. A., J. T. Hardy, C. I. Gibson, R. L. Schmidt, C. W. Apts, J. M. Gurtisen, and S. P. Joyce. 1982. Copper bioavailability to marine bivalves Macoma inquinata and shrimp Pandalus danae relationship to cupric ion activity. Mar. Environ. Res. 6(1): 13-26.

(21) Dobolyi, E. 1980. Identification of different phosphorus forms and their role in the eutrophication process of Lake Balaton, Hungary. In: Barica, J., and L. R. Mur (eds.). Developments in Hydrobiology. Vol. 2. Hypertophic Ecosystems; Workshop, Vaxjo, Sweden, Sept. 10-14, 1979. XVII+348 p. W. Junk Bv. Publishers, The Hague, Netherlands; Boston, MA, USA. Illus. Maps. ISBN 90-6193-752-3. 0(0): 13-22.

(22) Ernst, W. 1977. Determinatin of the bioconcentration potential of marine organisms a steady-state approach Part 1. Bioconcentration data for 7 chlorinated pesticides in mussels Mytilus edulis and their relation to solubility data. Chemosphere 6(11): 731-740.

(23) Everts, J. W., K. van Frankenhuzen, D. Roman, and J. H. Koeman. 1983. Side effects of experimental pyrethroid applications for the control of tsetse flies in a Riverine Forest habitat (Africa). Arch. Environ. Contam. Toxicol. 12: 91-97.

(24) Fellows, C. R., and P. L. Brezonik. 1981. Fertilizer flux into 2 Florida, USA, lakes via seepage. J. Environ. Qual. 10(2): 174-177.

(25) Foley, R. E., J. R. Spotila, J. P. Giesy, and C. H. Wall. 1978. Arsenic concentrations in water and fish from Chautauqua Lake, New York, USA. Environ. Biol. Fishes 3(4): 361-368.

(26) Forester, A. J. 1980. Monitoring the bioavailability of toxic metals in acid stressed shield lakes using pelecypod mollusks, clams, mussels. 14th Annual Conference on Trace Substances in Environmental Health, Columbia, MO, USA, June 2-5, 1980. Proc. Univ. Missouri Annu. Conf. Trace Subst. Environ. Health. 14(0): 142-147.

(27) Fox, P. J., and P. Mathiessen. 1982. Acute toxicity to fish of low dose aerosol applications of endosulfan to control tsetse fly in the Okarange Delta Botswana. Environ. Pollut. (Series A) 27: 129-142.

(28) Fukushima, S., H. Miyata, and T. Kashimoto. 1981. Detection and determination of poly chloro quater phenol in fish and shellfish. J. Food Hyg. Soc. Jpn. 22(5): 381-385.

(29) Gunkel, G. 1981. Bioaccumulation of a herbicide atrazine s triazine in the whitefish Coregonus fera uptake and distribution of the residue in fish. Arch. Hydrobiol. Suppl. 59(2-3): 252-287.

(30) Gunkel, G. 1981. A continuous flow apparatus for fish used for studying long-term bioaccumulation. Arch. Hydrobiol. Suppl. 59(2-3): 288-300.

(31) Gunkel, G. 1981. Bioaccumulation of a herbicide atrazine s triazine in the whitefish Coregonus fera uptake and distribution of the residue in fish. Arch. Hydrobiol. Suppl. 59(2-3): 252-287.

(32) Gunkel, G., and B. Streit. 1980. Mechanisms of bioaccumulation of a herbicide atrazine s triazine in a fresh water mollusk Ancylus fluviatilis and a fish Coregonus fera. Water Res. 14(11): 1573-1584.

(33) Guthrie, R. K., E. M. Davis, D. S. Cherry, and H. E. Murray. 1979. Bio magnification of heavy metals by organisms in a marine microcosm. Bull. Environ. Contam. Toxicol. 21(1-2): 53-61.

(34) Hallett, D. J., H. Shear, D. V. Weseloh, and P. Mineau. 1981. Surveillance of wildlife contaminants in the Great Lakes, USA, Canada. 21st Congress of the International Society of Limnology, Part 3, Kyoto, Japan, Aug.-Sept. 1980. Int. Ver. Theor. Agnew Limnol. Verh. 21(3): 1734-1740.

(35) Hall, R. J., and E. Kolbe. 1980. Bioconcentration of organo phosphorus pesticides to hazardous levels by amphibians. J. Toxicol. Environ. Health 6(4): 853-860.

(36) Hamelink, J. 1980. Bioavailability of chemicals in aquatic environments. In: Maki, A. W., K. L. Dickson, and J. Cairns, Jr. (eds.). Biotransformation and Fate of Chemicals in the Aquatic Environment; Proceedings of a Workshop; Pellston, MI, USA, Aug. 14-18, 1979. X+150 p. American Society for Microbiology: Washington, DC, USA. Illus. ISBN 0-914826-28-X. 0(0): 56-62.

(37) Hamelink, J. L., R. C. Waybrant, and P. R. Yant. 1977. Mechanisms of bioaccumulation of mercury and chlorinated hydro carbon pesticides by fish in lenthic ecosystems. In: Suffet, I. H. (ed.). Advances in Environmental Science and Technology, Vol. 8. Fate of Pollutants in the Environment. Symposium at the 165th National American Chemical Society Meeting in the Environmental Chemistry Division. Philadelphia, PA, USA, April 1975. XX+442 p. Illus. Maps. John Wiley and Sons, Inc., New York, NY, USA. ISBN 0-471-83539-0 (Part 1); ISBN 0-471-01803-1 (Part 2). pp. 261-282.

(38) Hardy, J. T., R. L. Schmidt, and C. W. Apts. 1981. Marine sediment and interstitial water effects on bioavailability of cadmium to gills of the clam Protothaca staminea. Bull. Environ. Contam. Toxicol. 27(6): 798-805.

(39) Hurst, J. W., and C. M. Yentsch. 1981. Patterns of intoxication of shellfish in the Gulf of Maine, USA, coastal waters. Can. J. Fish. Aquat. Sci. 38(2): 152-156.

(40) Imanaka, M., K. Matsunaga, A. Shigeta, and T. Ishida. 1981. Oxadiazon residues in fish and shellfish. J. Pestic. Sci. 6(4): 413-418.

(41) Ishikawa, K., S. Suzuki, N. Sato, K. Takatsuki, and K. Sakai. 1981. Analytical method for di-phenyl ether herbicides in fish and shellfish studies on residual di-phenyl ether herbicides in foods 2. J. Food Hyg. Soc. Jpn. 22(1): 56-59.

(42) Jensen, A. L., S. A. Spigarelli, and M. M. Thommes. 1982. Polychlorinated biphenyl uptake by 5 species of fish in Lake Michigan, Green Bay of Lake Michigan and Cayuga Lake, New York, USA. Can. J. Fish. Aquat. Sci. 39(5): 700-709.

(43) Jordan, C. F., and R. Herrera. 1981. Tropical rain forests are nutrients really critical. Am. Nat. 117(2): 167-180.

(44) Ketchu, B. H. 1980. Marine industrial pollution. In: Sears, M., and D.Merriman (ed.). Oceanography: The Past; 3rd International Congress on the History of Oceanography, Woods Hole, MA, USA, Sept. 22-26, 1980. XX+812 p. Springer-Verlag, New York, NY, USA; Berlin, West Germany. Illus. Maps. ISBN 0-387-90497-2; ISBN 3-540-90497-2. 0(0): 397-413.

(45) Kimmel, E. C., J. E. Casida, and R. H. Fish. 1980. Bio organo tin chemistry microsomal mono oxygenase and mammalian metabolism of cyclo hexyl tin compounds including the miticide cyhexatin. J. Agric. Food Chem. 28(1): 117-122.

(46) Koshino, M. 1977. Incoming and outgoing of fertilizer nutrients in cropped lands. In: Fukushima, Y. (ed.). Science for Better Environment. Proceedings of the International Congress on the Human Environment (HESC). Kyoto, Japan, Nov. 17-26, 1975. XIV+992 p. Illust. Maps. Pergamon Press: New York, NY, USA; Oxford, England. ISBN 0-08-021948-9. pp. 206-214.

(47) Kuehl, D. W. 1981. Unusual poly halogenated chemical residues identified in fish tissue from the environment. Chemosphere 10(3): 231-242.

(48) Landner, L., K. Lindstroem, M. Karlsson, J. Nordin, and L. Soerensen. 1977. Bioaccumulation in fish of chlorinated phenols from kraft pulp mill belachery effluents. Bull. Environ. Contam. Toxicol. 18(6): 663-673.

(49) Laseter, J. L., I. R. Deleon, and P. C. Remele. 1978. Determination of mirex in fish by gas chromatography and gas chromatography mass spectrometry computer system. Anal. Chem. 50(8): 1169-1172.

(50) Laska, A. L., C. K. Bartell, D. B. Condie, J. W. Brown, R. L. Evans, and J. L. Laseter. 1978. Acute and chronic effects of hexachlorobenzene and hexachlorobutadiene in red swamp crayfish Procambarus clarki and selected fish species. Toxicol. Appl. Pharmacol. 43(1): 1-12.

(51) Laube, V., S. Ramamoorthy, and D. J. Kushner. 1979. Mobilization and accumulation of sediment bound heavy metals by algae. Bull. Environ. Contam. Toxicol. 21(6): 763-770.

(52) Lee, H., II, and R. C. Swartz. 1980. Biological processes affecting the distribution of pollutants in marine sediments 2. Biodeposition and bioturbation. In: Baker, R. A. (ed.). Contaminants and Sediments, Vol. 2, Analysis, Chemistry, Biology. XVIII+627 p. Ann Arbor Science Publishers, Inc., Ann Arbor, MI, USA. Illus. ISBN 0-250-40307-2. 0(0): 555-606.

(53) Leland, H. V., S. N. Luoma, and J. M. Fielden. 1979. Bioaccumulation and toxicity of heavy metals and related trace elements. J. Water Pollut. Control Fed. 51(6): 1592-1616.

(54) Lemke, A. E. 1978. Installation of a marine bioassay laboratory at KISR (Kuwait Institute for Scientific Research). Serial No. FMR/SC/OPS/78/231(FIT). United Nations Development Programme. United Nations Educational, Scientific and Cultural Organization. Paris 1978.

(55) Lemke, A. E., W. A. Brungs, and B. J. Halligan. 1978. Manual for construction and operation of toxicity-testing proportional diluters. USEPA, EPA-600/3-78-072.

(56) Lyes, M. C. 1979. Bioavailability of hydro carbon from water and sediment to the marine worm Arenicola marina. Mar. Biol. (Berl.) 55(2): 121-128.

(57) McCain, B. B., H. O. Hodgins, W. D. Gronlund, J. W. Hawkes, D. W. Brown, M. S. Myers, and J. H. Vandermeulen. 1978. Bioavailability of crude oil from experimentally oiled sediments to English sole Parophrys vetulus and pathological consequences. J. Fish. Res. Board Can. 35(5): 657-664.

(58) Middlebrooks, E. J. 1979. Environmental science and technology industrial pollution control. Vol. 1. Agro Industries. XVI+445 p. John Wiley and Sons, Inc., New York, NY, USA. Chichester, England, Illus. ISBN 0-471-04779-1. 0(0).. XVI+445 p.

(59) Mohanaranga, R. D., and A. S. Murty. 1980. Toxicity, biotransformation and elimination of endosulfan in Anabas testudineus. Indian J. Exp. Biol. 18(6): 664-666.

(60) Mommaerts, J. P., and L. Borsu-Elgman. 1980. Comparative study of phytoplankton production in 2 trout ponds in the hilly section of Belgium, 1967-1969. Bull. Inst. R. Sci. Nat. Belg. Biol. 52(2): 1-31.

(61) Moss, B., D. E. Forrest, and G. Phillips. 1979. Eutrophication and paleo limnology of 2 small medieval man-made lakes. Arch. Hydrobiol. 85(4): 409-425.

(62) Muir, D. C. G., and N. P. Grift. 1981. Environmental dynamics of phosphate esters 2. Uptake and bioaccumulation of 2 ethylhexyldiphenyl phosphate and diphenyl phosphate by fish. Chemosphere 10(8): 847-856.

(63) Nash, R. G. 1981. Determining environmental fate of pesticides with micro agro ecosystems. 182nd ACS (American Chemical Society) National Meeting, New York, NY, USA. August 23-28, 1981. Abstr. Pap. Am. Chem. Soc. 182(0): Pest 62.

(64) Nash, R. G., and M. L. Beall, Jr. 1980. Fate of maneb and zineb fungicides in micro agro ecosystem chambers. J. Agric. Food Chem. 28(2): 322-330.

(65) Nash, R. G., M. L. Beall, Jr., and W. G. Harris. 1977. Toxaphene and DDT losses from cotton in an agro ecosystem chamber. J. Agric. Food Chem. 25(2): 336-341.

(66) Neilsen, G. H., and A. F. MacKenzie. 1977. Losses of soluble and extractable sediment phosphorus from agricultural watersheds in southwestern Quebec and southeastern Ontario. Can. J. Soil Sci. 57(4): 465-476.

(67) Nigg, H. N., J. C. Allen, and R. W. King. 1979. Behavior of parathion residues in the Florida cultivar valencia orange agro ecosystem. J. Agric. Food Chem. 27(3): 578-582.

(68) Norstrom, R. J., D. J. Hallett, and R. A. Sonstegard. 1978. Coho salmon Oncorhynchus kisutch and herring gulls Larus argentatus as indicators of organo chlorine contamination in Lake Ontario. J. Fish. Res. Board Can. 35(11): 1401-1409.

(69) Olsen, P., and E. Willen. 1980. Phytoplankton response to sewage reduction in Vattern, a large oligotrophic lake in central Sweden. Arch. Hydrobiol. 89(1-2): 171-188.

(70) Ower, J., C. F. Cresswell, and G. C. Bate. 1981. The effects of varying culture nitrogen and phosphorus levels on nutrient uptake and storage by the water hyacinth Eichhornia crassipes. Hydrobiologia 85(1): 17-22.

(71) Perfect, J. 1980. The environmental impact of DDT in a tropical agro ecosystem. Ambio. 9(1): 16-21.

(72) Philippart, J. C. 1980. The effects of organic pollution and eutrophication on the fish fauna of the River Semois, France. Ann. Limnol. 16(1): 77-90.

(73) Pierson, K. B. 1981. Effects of chronic zinc exposure on the growth, sexual maturity, reproduction and bioaccumulation of the guppy Poecilia reticulata. Can. J. Fish. Aquat. Sci. 38(1): 23-31.

(74) Rao, S. S., R. E. Kwiatkowski, and A. A. Jurkovic. 1979. Distribution of bacteria and chlorophyll a at a nearshore station in Lake Ontario, Canada. Hydrobiologia 66(1): 33-40.

(75) Roberts, J. R., and M. J. Boddington. 1982. Dynamics of dioxins as it pertains to indicators of pollution. 73rd Annual Meeting of the American Oil Chemists' Society, Toronto, Ontario, Canada. May 2-6, 1982. J. Am. Oil Chem. Soc. 59(4): 279A.

(76) Sanai, M., and J. Shayegan. 1979. Water pollution abatement through reuse of municipal waste water in agricultural systems. Environ. Pollut. 18(2): 119-130.

(77) Sasaki, K., M. Takeda, and M. Uchiyama. 1982. Accumulation and elimination of environmental pollutants, organo phosphoric tri esters and pesticides by killifish Oryzias latipes and goldfish Carassius auratus. 8th Symposium on Environmental Pollutants and Toxicology, Sendai, Miyagi, Japan, Oct. 8-9, 1981. Eisei Kagaku. 28(1): 32.

(78) Schmitt, C. J., and P. V. Winger. 1980. Factors controlling the fate of pesticides in rural watersheds of the lower Mississippi River, Alluvial Valley, USA. In: Sabol, K. Transactions of the North American Wildlife and Natural Resources Conference, No. 45. Balancing Natural Resources Allocations, Miami Beach, FL, USA, March 22-26, 1980. IX+478 p. Wildlife Management Institute: Washington, DC, USA. Illus. Paper 0(0): 354-375.

(79) Schneider, R. 1981. Polychlorinated biphenyls in cod tissues from the western Baltic significance of equilibrium partitioning and lipid composition in the bioaccumulation of lipophilic pollutants in gill breathing animals. Meeresforschung 29(2): 69-79.

(80) Sivalingam, P. M., and R. Ismail. 1981. Cladophora fascicularis as a prominent global algal monitor for trace metal pollutants 1. High concentration stresses and modes of biodeposition. Jpn. J. Phycol. 29(3): 171-179.

(81) Skea, J. C., H. A. Simonin, H. J. Dean, J. R. Colquhoun, J. H. Spagnoli, and G. D. Veith. 1979. Bioaccumulation of Aroclor 1016 in Hudson River fish. Bull. Environ. Contam. Toxicol. 22(3): 332-336.

(82) Soermarwoto, O. 1977. Nitrogen in tropical agriculture Indonesia as a case study. Ambio. 6(2-3): 162-165.

(83) Stolbunov, A. K. 1981. Production and decomposition of organic matter and bacterio plankton under eutrophication conditions. Water Resour. 8(1): 71-84.

(84) Stone, C. L., M. R. S. Fox, and K. S. Hogye. 1981. Bioavailability of lead in oysters fed to young Japanese quail. Environ. Res. 26(2): 409-421.

(85) Stora, G., and G. Bellan. 1977. Use of the concept of lethal concentration in marine invertebrate toxicology. Rev. Int. Oceanogr. Med. (48): 125-130.

(86) Sudershan, P., and M. A. Q. Khan. 1980. Biotransformations of carbon-14 labeled endrin and dieldrin by bluegill fish Lepomis macrochirus. 2nd International Congress on Toxicology, Brussels, Belgium, July 6-11,1980. Toxicol. Letters (Amst.). 0 (Spec. Issue 1): 38.

(87) Svardson, G., and G. Molin. 1981. The impact of eutrophication and climate on a warm water fish community. Inst. Freshwater Res. Drottningholm Rep. 0(59): 142-151.

(88) Taylor, R., T. Bogacka, J. Groba, and A. Majewski. 1977. Effect of wastes from phosphatic fertilizer production on the Marwa Wisla River, Poland. Pol. Arch. Hydrobiol. 24(1): 155-176.

(89) Tomizawa, C., and H. Kazano. 1979. Environmental fate of rice paddy pesticides in a model ecosystem. J. Environ. Sci. Health Part B Pestic. Food Contam. Agric. Wastes 14(2): 121-152.

(90) Topping, G. 1982. Report on the 6th International Council for the Exploration of the Sea Trace Metal Inter Comparison Exercise for Cadmium and Lead in Biological Tissue. Int. Counc. Explor. Sea Coop. Res. Rep. 0(111): 1-28.

(91) Trujillo, D. A., L. E. Ray, H. E. Murray, and C. S. Giam. 1982. Bioaccumulation of penta chloro phenol by killifish Fundulus similis. Chemosphere 11(1): 25-32.

(92) Vandermeulen, J. H., B. F. N. Long, and T. P. Ahern. 1981. Bioavailability of stranded Amoco-Cadiz oil as a function of environmental self cleaning. April 1978-Jan. 1979. Amoco Cadiz: Consequences D'Une Pollution Accidentelle Par Les Hydrocarbures; Actes Du Colloque International Centre Oceanologique De Bretagne Brest (France) 19-22 Novembre 1979 (Amoco Cadiz: Consequences of Accidental Pollution by Hydrocarbons; Proceedings of the International Symposium Centre Oceanologique De Bretagne Brest (France), Nov. 19-22, 1979). VI+881 p. Publie Par Le Centre National Pour L'Exploitation Des Oceans: Paris, France. Illus. Maps. ISBN 02-90272-09-9. 0(0): 585-598.

(93) Verlencar, X. N., and C. D'Silva. 1977. Water quality characteristics at Velsao and Colva Beaches of Goa. Indian J. Mar. Sci. 6(2): 111-113.

(94) Wang, K., B. Rott, and F. Korte. 1982. Uptake and bioaccumulation of 3 polychlorinated biphenyls by Chlorella fusca. Chemosphere 11(5): 525-530.

(95) Welte, E., and F. Timmermann. 1977. The degree to which sewage of agricultural origin is responsible for the eutrophication and pollution of streams and rivers. Ber. Landwirtsch. 55(4): 663-682.

(96) Wiklander, L. 1977. Leaching of plant nutrients in soils. Part 4. Contents in drainage water and ground water. Acta Agric. Scand. 27(3): 175-189.

(97) Wroblewski, R. J. 1979. Physiological and behavioral characterization of the action of chlorfenvinphos on fish Lebistes reticulatus. Pol. Arch. Hydrobiol. 26(3): 427-456.

(98) Young, D. R., and T. C. Heesen. 1978. DDT poly chlorinated bi phenyl and chlorinated benzenes in the marine ecosystem off southern California. In: Jolley, R. L., H. Gorchev, and D. H. Hamilton, Jr. (eds.). Water Chlorination. Environmental Impact and Health Effects, Vol. 2. Proceedings of the 2nd Conference. Gatlinburg, TN, USA, Oct. 31 - Nov. 4, 1977. XVIII+909 p. Illus. Maps. Ann Arbor Science Publishers, Inc. Ann Arbor, MI, USA. ISBN 0-250-40201-7. pp. 267-290.

(99) Zamuda, C., and W. G. Sunda. 1982. Bio availability of dissolved copper to the American oyster Crassostrea virginica 1. Importance of chemical speciation. Mar. Biol. (Berl). 66(1): 77-82.